NOISE STUDY REPORT
Highway 1 Soquel to Morrissey Auxiliary Lanes Project

Santa Cruz County, California

PM 14.96/15.94 (KP 24.08/25.65)

EA: 05-0F6500

California Department of Transportation

District 5
50 Higuera Street
San Luis Obispo, CA 93401

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EXECUTIVE SUMMARY

The purpose of this study is to evaluate the potential traffic noise impacts at noise sensitive receptors resulting from the proposed Highway 1 Soquel to Morrissey Auxiliary Lanes Project. The project would add one 12-foot (3.7-meter) wide auxiliary lane from the Soquel Avenue on-ramp to the Morrissey Boulevard off-ramp in the northbound direction and extend a 12-foot (3.7-meter) wide lane between La Fonda Avenue and the Soquel Avenue off-ramp in the southbound direction, with 10-foot (3.0-meter) outside shoulders between the Soquel Avenue and Morrissey Boulevard interchanges. An auxiliary lane extends from the on-ramp of one interchange to the off-ramp at the next interchange and is designed to separate traffic movements entering and exiting the freeway from mainline traffic. This project is defined as Type 1 by Title 23, Part 772 of the Code of Federal Regulations (23 CFR 772); therefore, a full noise assessment is required.

Residential land uses are predominant along most of the Highway 1 project corridor between Soquel Drive and Morrissey Boulevard. Noise sensitive receptors that may be affected by the project include single- and multi-family residences, Harbor High School, Carden School, and Santa Cruz Community Church that are located in close proximity to the project corridor.

Noise measurements were taken at four locations within the Auxiliary Lanes Project limits in April of 2004 and one additional location in May of 2009. The primary objectives of the measurements were for evaluating the existing noise environment and calibrating the noise prediction model. Short-term measurements were conducted at four sites for 20 minutes each, and a long-term measurement was conducted at one location for at least 24 hours.

Indoor/outdoor noise measurements were also conducted in Carden School to determine the building shell noise reduction. This school did not exist at the present location during 2004 noise measurements. There are two buildings that are directly facing the highway. One of the two buildings is currently used as a multi-purpose room where students have activities and afterschool programs. This building has single-pane aluminum slide windows and no air condition (A/C) unit. The other building is a modular classroom building that is equipped with separate wall-mounted A/C units and dual-pane windows.

As of February 2009, two soundwalls have been built along Highway 1 west of La Fonda Bridge as part of the State Route 1/State Route 17 Merge Lanes Project within the limits of this study. This project was completed in the Fall of 2008. As a result, peak hour traffic noise levels have been changed at receptors behind these newly constructed soundwalls since Year 2004 noise measurements. Therefore, existing noise levels behind these soundwalls were modeled using the Federal Highway Administration's Traffic Noise Model (TNM).

The modeled noise level at the calibration location was higher than the measured noise levels at the calibration location. Heavy vegetation along Highway 1 appears to be providing some noise attenuation between roadways and receptors. Since the deviation at the calibration site was within 2 dB difference, no calibration factor was applied to the modeling.

The worst-case traffic noise occurs when traffic is operating under Level-of-Service C (LOS C) conditions. Under LOS C conditions, traffic is heavy, but remains free flowing. LOS C volume of 1,800 vehicles-per-hour (vph) per lane was utilized in modeling Highway 1 mainline traffic volume. Year 2015 ramp traffic volumes were compared to the LOS C volume of 1,000 vph per lane, and the lesser of the two was used in modeling ramp traffic.

Peak hour traffic noise levels at 43 single-family residences as well as outdoor use areas of Carden School and Santa Cruz Community Church along Highway 1 within the project limits would approach or exceed the Noise Abatement Criteria. Six soundwalls on Highway 1 shoulders or on the right-of-way lines are considered feasible, which means they would provide a minimum of 5-dB noise reduction. The total combined length of these soundwalls is 3,505 feet (1,068 meters). These six soundwalls would be feasible for a total of 31 single-family residences and Carden School of Santa Cruz (3 frontage units). Noise abetment would not be feasible for 12 single-family houses and one church which would have future traffic noise levels approaching or exceeding the Noise Abatement Criteria. Soundwall S177 would tie into an existing soundwall on its west end to make it feasible for the school and two houses. Soundwall S178 would replace the existing soundwall on the back of two single-family houses.

If Soundwalls S177 and S175 are determined to be unreasonable, providing acoustical treatment would still be required for the multi-purpose room of Carden School and a single family house because they both would be severely impacted. Installation of dual-pane windows with a minimum Sound Transmission Class (STC) rating of 32 should provide noise abatement for the interior of the multi-purpose room of the school and rooms of the single-family house facing the freeway. Additionally, multi-purpose room of Carden School would need an A/C unit to provide climate control when windows are closed. An A/C unit may also be needed for the single-family house if it does not have one.

If Soundwall S178 is determine to be unreasonable, then future predicted traffic noise levels at two single-family houses would exceed Noise Abatement Criteria. Table ES-I provides summaries of the recommended barriers, including the number of benefited residences, reasonable allowance per residence, and reasonable allowance cost per barrier.

Construction noise is regulated by California Department of Transportation's Standard Specifications, May 2006, Section 7-1.01I, Sound Control Requirements. The requirements state that construction noise levels generated during construction shall comply with applicable local, state, and federal regulations and that all equipment shall be fitted with adequate mufflers according to the manufactures' specifications.

Temporary construction noise impacts would be unavoidable during La Fonda Avenue Bridge demolition/reconstruction. Four single-family residences that are adjacent to the bridge on both sides of the freeway would receive temporary construction noise impact.

TABLE ES-I – SUMMARY OF FEASIBLE BARRIERS AND COST ALLOWANCES

Barrier No.	Receptor No.	Type[1] and No. of Benefited Residences	Barrier Location/ Hwy. Side	Barrier Height/Total Length, ft (m)	Reasonable Cost per Residence	Reasonable Allowance Cost Per Barrier	Estimated Construction Cost
S172	R17, R18	12 SFR	R/W Northbound	8 ft (2.4 m) to 10 ft (3.0 m) / 822 ft (250 m)	$60,000	$720,000	$297,780
S173	R3	1 SFR	R/W Southbound	16 ft (4.9 m) / 417 ft (127 m)	$48,000	$48,000	$248,920
S175	R5	1 SFR	R/W Southbound	10 ft (3.0 m) / 247 ft (75 m)	$58,000	$58,000	$76,880
S176	R19, R20	13 SFR	R/W / Shoulder Northbound	10 ft (3.0 m) and 14 ft (4.3 m) / 857 ft (261 m)	$58,000	$754,000	$373,800
S178	R21	2 SFR	R/W Northbound	14 ft (4.3 m) / 255 ft (78 m)	$52,000	$104,000	$129,000
S177	R6A to R6	2 SFR 1 SCH (3 frontage units)	Shoulder Southbound	14 ft (4.3 m) / 907 ft (276 m)	$44,000	$220,000	$481,600

Notes:
1. Land Use: SFR - single-family residence; SCH - school.

1.0 INTRODUCTION

The purpose of this study is to evaluate the potential traffic noise impacts at noise sensitive receptors resulting from the proposed Highway 1 Soquel to Morrissey Auxiliary Lanes Project. The project would add one 12-foot (3.7-meter) wide auxiliary lane from the Soquel Avenue on-ramp to the Morrissey Boulevard off-ramp in the northbound direction and extend a 12-foot (3.7-meter) wide lane between La Fonda Avenue and the Soquel Avenue off-ramp in the southbound direction, with 10-foot (3.0-meter) outside shoulders between the Soquel Avenue and Morrissey Boulevard interchanges. An auxiliary lane extends from the on-ramp of one interchange to the off-ramp at the next interchange and is designed to separate the movement of traffic entering and exiting the freeway from mainline traffic. This project is defined as a Type 1 project by Title 23, Part 772 of the Code of Federal Regulations (23 CFR 772); therefore, a full noise assessment is required.

This noise study includes (a) long-term noise measurements; (b) short-term measurements; (c) school indoor/outdoor measurements; (d) roadway traffic noise prediction/modeling using the Federal Highway Administration Traffic Noise Model (TNM); and (e) noise abatement/mitigation recommendations.

2.0 PROJECT DESCRIPTION

The proposed project extends for a distance of 0.98 mile, from the southbound Soquel Avenue off-ramp to the northbound Morrissey Boulevard on-ramp (post mile 14.96 to post mile 15.94) in the City of Santa Cruz, Santa Cruz County, California. Figure 1 is a map of the project vicinity and location.

The purpose of the Soquel to Morrissey Auxiliary Lanes Project is to improve traffic conditions for lane-changing and merging movements on Highway 1 between Soquel Avenue and Morrissey Boulevard and improve pedestrian and bicycle access and safety.

Identified needs include recurrent congestion from impeded lane-changing and merging movements, queuing traffic from the southbound bottleneck at the La Fonda Avenue overcrossing, and limited pedestrian and bicycle access crossing Highway 1 in the project area.

Two alternatives are under consideration: one Build Alternative and the No-Build Alternative.

Build Alternative

The Build Alternative would add one 12-foot-wide auxiliary lane from the Soquel Avenue on-ramp to the Morrissey Boulevard off-ramp in the northbound direction and extend a 12 foot-wide lane from about 500 feet north of the La Fonda Avenue overcrossing to the Soquel Avenue off ramp in the southbound direction. The outside shoulders between the Soquel Avenue and Morrissey Boulevard interchanges would be widened to 10 feet from a variable width of 6.56 to 10 feet northbound and 8 to 10 feet southbound. Auxiliary lanes are not designed for use by through traffic. The project also would replace the La Fonda Avenue overcrossing.

An auxiliary lane would be constructed northbound from the Soquel Drive on-ramp to the Morrissey Boulevard northbound off-ramp (0.7 mile). On southbound Highway 1, the new outside (1.3-mile) lane constructed as part of the State Route 1/ State Route 17 Merge Lanes Project would be extended (0.3 mile) from north of the La Fonda Avenue overcrossing to the

Soquel Avenue exit ramp, for a total length of 1.6 miles. This extended lane would be “exit only” at Soquel Avenue, and the widening would eliminate the outside lane-drop north of La Fonda. No changes would be made to the Soquel Avenue or Morrissey Boulevard ramps.

Retaining walls are proposed at several locations to reduce the footprint of the Build Alternative, keep the improvements within the existing highway right-of-way and minimize impacts to wetlands and other waters of the U.S. The soundwalls constructed under the State Route 1/State Route 17 Merge Lanes Project adjacent to the Morrissey Boulevard northbound off-ramp and southbound on-ramp would remain in place.

Additionally, the La Fonda Avenue overcrossing would be replaced and widened to accommodate the proposed auxiliary lanes. The new bridge would provide for 11-foot-wide traffic lanes as well as five-foot-wide bicycle lanes and six-foot-wide pedestrian sidewalks in both directions.

The project also would demolish the existing La Fonda Avenue overcrossing, including existing roadway shoulders, earthwork and fill, and would require temporary easements for replacement of the La Fonda Avenue overcrossing and construction of a temporary pedestrian/bicycle crossing. If reconstruction of the La Fonda Avenue overcrossing would extend beyond one summer, a temporary pedestrian/ bicycle bridge would be constructed for use during the construction period, or shuttle service would be provided to service students and other school patrons that currently use the La Fonda Avenue overcrossing. Coordination with the school principals and the timing of the reconstruction (if during the school year) would determine which measure to implement. Furthermore, the project would install an American Disabilities Act-compliant raised crosswalk, at the south end of the La Fonda Avenue bridge near the entrance to Harbor High School.

Local street improvements between Elk Street and San Juan Avenue are included at the request of Santa Cruz City Public Works to improve pedestrian access and safety parallel to Highway 1 at the Morrissey Boulevard Interchange. New five-foot sidewalks, curb, and gutter would be constructed in the gaps between existing segments on the north side of Rooney Street and Morrissey Boulevard. The work would install four accessible driveway approaches and four pedestrian ramps in compliance with the Americans with Disabilities Act.

No-Build Alternative

The No-Build Alternative would not address the project purpose and need, but offers a basis for comparison with the Build Alternative. It assumes no major construction on Highway 1 through the project limits other than planned and programmed improvements and continued routine maintenance. The only planned and programmed improvement contained in the 2005 Regional Transportation Plan is the State Route 1/State Route 17 Merge Lanes Project, which recently completed construction and is in the landscape phase anticipated to be completed in 2009, with plant establishment activities to continue through 2012. The State Route 1/State Route 17 Merge Lanes Project is considered as part of existing conditions for the Soquel to Morrissey Auxiliary Lanes Project. The Highway 1 High Occupancy Vehicle (HOV) Lane Widening Project is also planned, but is not included in the No-Build Alternative, as it is not yet programmed and will not be completed by the 2015 opening year for the Soquel to Morrissey Auxiliary Lanes Project.

Figure 1 shows the project vicinity map and Figure 2 depicts the project limits.

FIGURE 1 – PROJECT VICINITY MAP

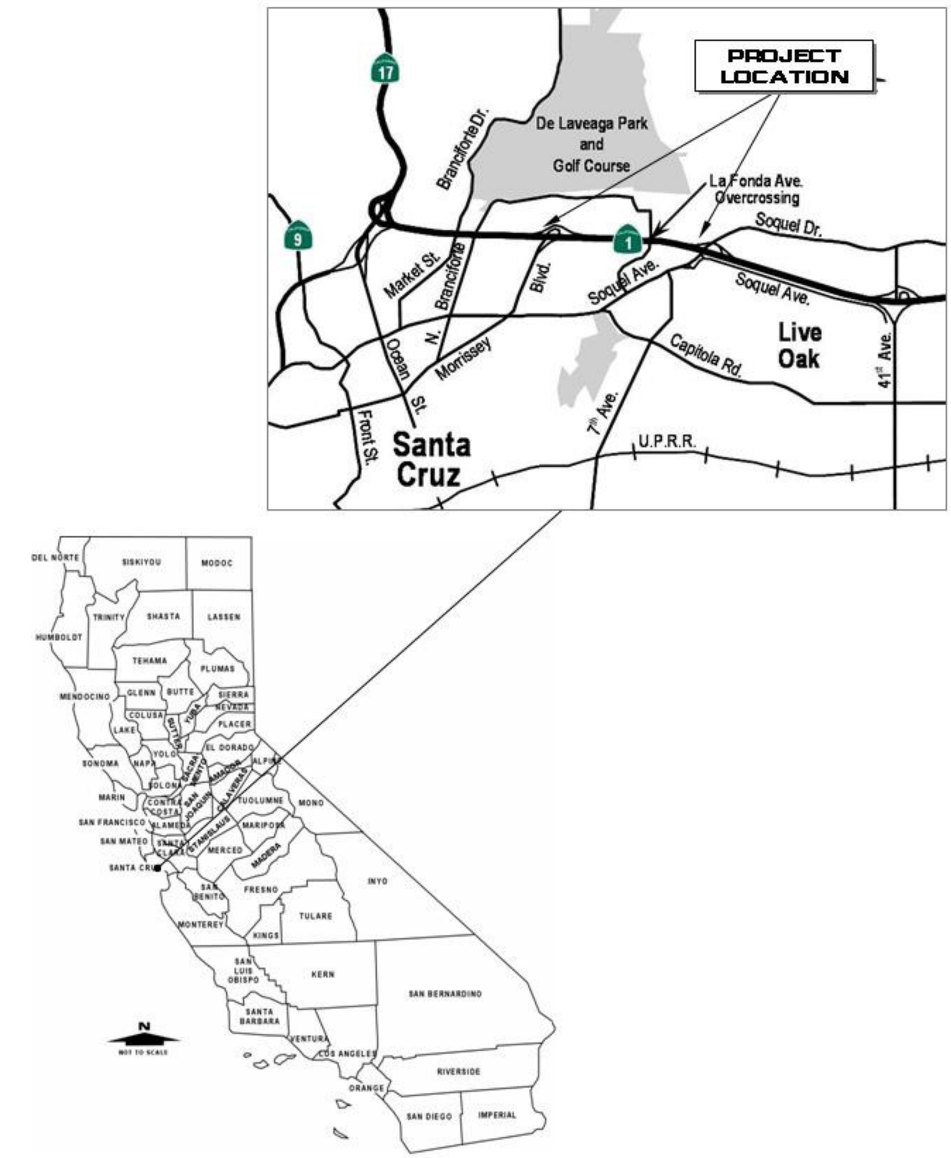
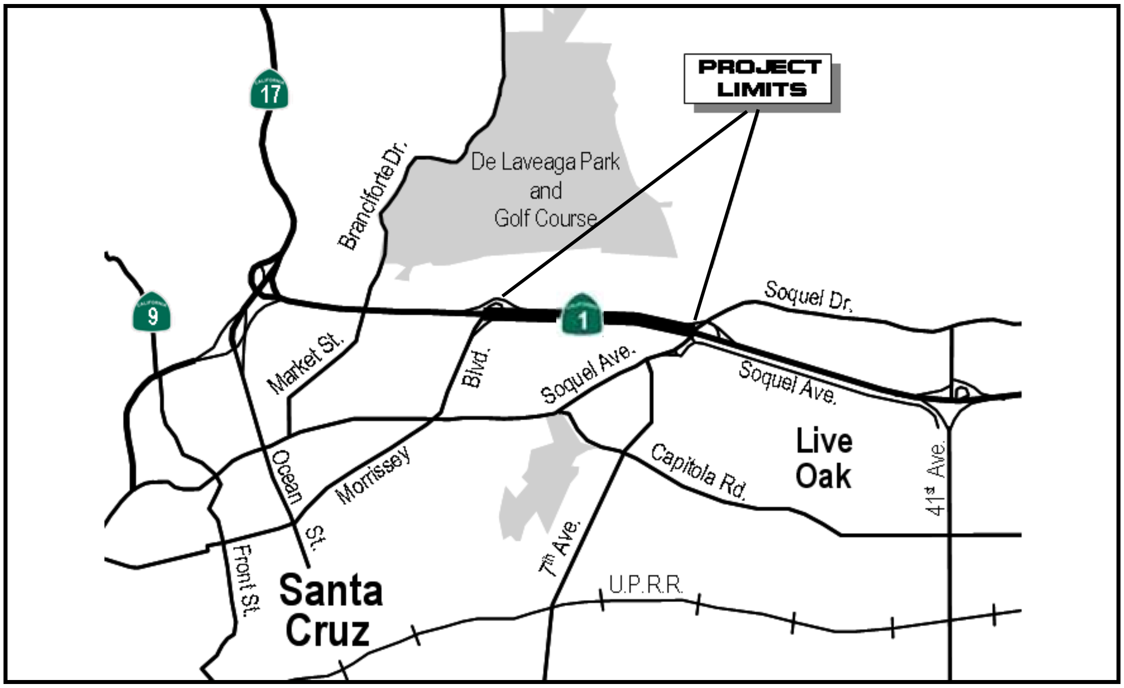


Figure 1
Highway 1 Soquel Avenue to Morrissey Boulevard Auxiliary Lane Project
EA 05-0F650K PM 14.96/15.94, KP 24.08/25.65
PROJECT LOCATION AND VICINITY

FIGURE 2 – PROJECT STUDY LOCATION



3.0 FUNDAMENTALS OF TRAFFIC NOISE

A brief discussion of fundamental traffic noise concepts is provided in this section.

Sound, Noise, and Acoustics

Sound is a disturbance created by a moving or vibrating source in a gaseous or liquid medium or the elastic stage of a solid and is capable of being detected by the hearing organs. Sound may be thought of as the mechanical energy of a vibrating object transmitted by pressure waves through a medium to a human ear. For traffic sound, the medium of concern is air. *Noise* is defined as sound that is loud, unpleasant, unexpected, or undesired.

Frequency and Hertz

A continuous sound can be described by its *frequency* (pitch) and its *amplitude* (loudness). Frequency relates to the number of pressure oscillations per second. Low-frequency sounds are low in pitch, like the low notes on a piano, whereas high-frequency sounds are high in pitch, like the high notes on a piano. Frequency is expressed in terms of oscillations, or cycles, per second. Cycles per second are commonly referred to as Hertz (Hz). The extreme range of frequencies that can be heard by the healthiest human ears spans from 16–20 Hz on the low end to about 20,000 Hz (or 20 kHz) on the high end.

Sound Pressure Levels and Decibels

The *amplitude* of a sound determines its loudness. The loudness of a sound increases and decreases with respect to its increasing and decreasing amplitude. Sound pressure amplitude is measured in units of micro-Newtons per square meter (N/m^2), also called micro-Pascal (µPa). One µPa is approximately one hundred billionths (0.00000000001) of normal atmospheric pressure. S*ound pressure level* (L_p) is used to describe in logarithmic units the ratio of actual sound pressures to a reference pressure squared. These units are called decibels, abbreviated dB.

Addition of Decibels

Because decibels are logarithmic units, sound pressure levels cannot be added or subtracted by ordinary arithmetic means. When two sounds of equal L_p are combined, they will produce a combined L_p, which is 3 dB greater than the original individual L_p. In other words, sound energy must be doubled to produce a 3-dB increase. If two sound levels differ by 10 dB or more, the combined L_p is equal to the higher L_p; in other words, the lower sound level does not increase the higher sound level.

A-Weighted Decibels

Sound pressure level alone is not a reliable indicator of loudness. The frequency, or pitch, of a sound also has a substantial effect on how humans will respond. Although the intensity (energy per unit area) of the sound is a purely physical quantity, the loudness or human response is determined by the characteristics of the human ear. In general, the healthy human ear is most sensitive to sounds between 1,000 Hz and 5,000 Hz, and it perceives a sound within that range as being more intense than a sound of higher or lower frequency with the same magnitude. A series of L_p adjustments is usually applied to the sound level at different frequencies to approximate the frequency response of the human ear. These adjustments are referred to as a *weighting network*. The A-scale weighting network approximates the frequency response of the average young ear when listening to most ordinary sounds. Noise levels for traffic noise reports are typically reported in terms of A-weighted decibels (dBA). In environmental noise studies, A-weighted L_ps are commonly referred to as noise levels. Figure 3 shows typical A-weighted noise levels.

Human Response to Changes in Noise Levels

It is widely accepted that the average healthy ear can barely perceive noise level changes of 3 dB. A change of 5 dB is readily perceptible, and a change of 10 dB is perceived as being twice or half as loud. As discussed previously, doubling of sound energy results in a 3 dB increase in the sound level, which means that doubling of sound energy (e.g., doubling the volume of traffic on a highway) would result in a barely perceptible change in sound level.

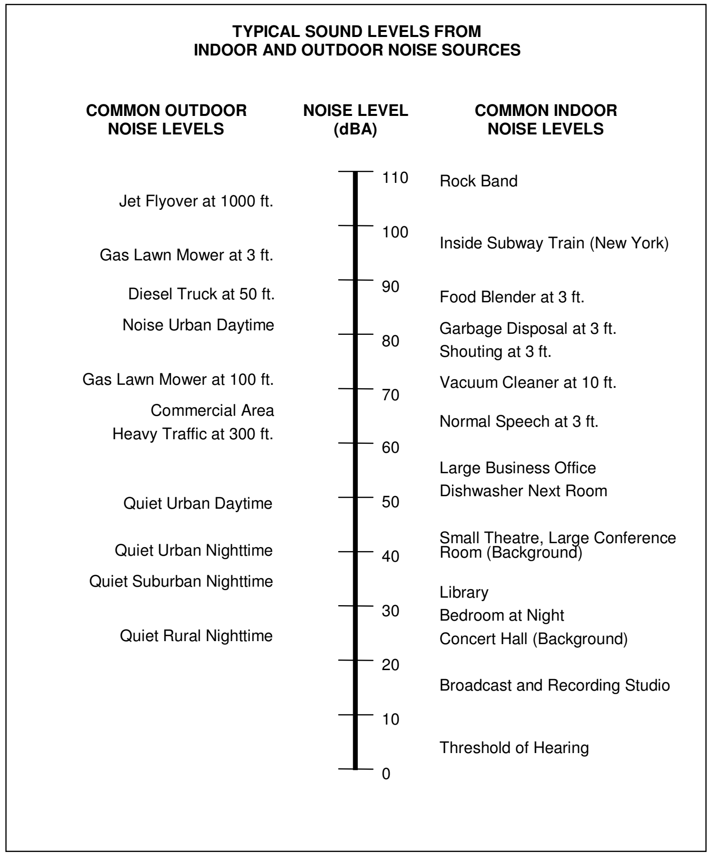


FIGURE 3 – TYPICAL A-WEIGHTED NOISE LEVELS

Noise Descriptors

Noise in our daily environment fluctuates over time. Some noise levels occur in regular patterns, others are random. Some noise levels fluctuate rapidly, others slowly. Some noise levels vary widely, others are relatively constant. Various noise descriptors have been developed to describe time-varying noise levels. The following is a list of the noise descriptors most commonly used in traffic noise analysis:

- **Equivalent Sound Level ($L_{eq(h)}$)** - $L_{eq(h)}$ represents an average of the sound energy occurring over a specified period. $L_{eq(h)}$ is, in effect, the steady-state sound level that, in a stated period, would contain the same acoustical energy as the time-varying sound that actually occurs during the same period. The 1-hour A-weighted equivalent sound level, $L_{eq(h)}$, is the energy average of the A-weighted sound levels occurring during a 1-hour period and is the basis for Noise Abatement Criteria (NAC) used by the Caltrans and the FHWA.
- **Maximum Sound Level (L_{max})** - L_{max} is the highest instantaneous sound level measured during a specified period.
- **Insertion Loss (I.L.)** – I.L. is the actual noise level reduction at a specific receiver due to construction a noise barrier between the noise source (traffic) and

the receiver. Generally, it is the net effect of the soundwall attenuation and the loss due to ground effects.

Sound Propagation

When sound propagates over a distance, it changes in both level and frequency content. The manner in which noise reduces with distance depends on the following factors:

- ***Geometric spreading*** - Sound from a small, localized source (i.e., a point source) radiates uniformly outward as it travels away from the source in a spherical pattern. The sound level attenuates (or drops off) at a rate of 6 dB for each doubling of distance. Highway noise is not a single, stationary point source of sound. The movement of the vehicles on a highway makes the source of the sound appear to emanate from a line (i.e., a line source) rather than a point. This line source results in cylindrical spreading rather than the spherical spreading that results from a point source. The change in sound level from a line source is 3 dB per doubling of distance.

- ***Ground absorption*** - Most often, the noise path between the highway and the observer is very close to the ground. Noise attenuation from ground absorption and reflective wave canceling adds to the attenuation associated with geometric spreading. Traditionally, the excess attenuation has also been expressed in terms of attenuation per doubling of distance. For acoustically hard sites (i.e., those sites with a reflective surface, such as a parking lot or a smooth body of water, between the source and the receiver), no excess ground attenuation is assumed. For acoustically absorptive or soft sites (i.e., those sites with an absorptive ground surface, such as soft dirt, grass, or scattered bushes and trees, between the source and the receiver), an excess ground attenuation value of 1.5 dB per doubling of distance is normally assumed. When added to the geometric spreading, the excess ground attenuation results in an overall drop-off rate of 4.5 dB per doubling of distance for a line source and 7.5 dB per doubling of distance for a point source.

- ***Atmospheric effects*** - Research by Caltrans and others has shown that atmospheric conditions can have a significant effect on noise levels when noise receptors are located more than 60 meters (200 feet) from a highway. Wind has been shown to be the most important meteorological factor within approximately 150 meters (500 feet) of the source, whereas vertical air temperature gradients are more important for greater distances. Other factors such as air temperature, humidity, and turbulence also have significant effects.

4.0 FEDERAL AND STATE POLICIES AND PROCEDURES

Federal and state regulations, standards, and policies relating to traffic noise are discussed in detail in the California Department of Transportation's Traffic Noise Analysis Protocol (Protocol), (Caltrans, 2006). Protocol requirements apply to Type 1 projects. A Type 1 project is defined in Title 23, Part 772 of the Code of Federal Regulations (23 CFR 772) as a proposed federal or federal-aid highway project for the construction of a highway on a new location or the physical alteration of an existing highway that significantly changes either the horizontal or vertical alignment or increases the number of through traffic lanes. The Federal Highway Administration (FHWA) has clarified its interpretation of Type 1 projects by stating that a Type 1 project is any project that has the potential to increase noise levels at adjacent receptors. This includes projects to add interchange, ramp, HOV lanes, auxiliary lanes, or truck-climbing lanes to an existing highway. The Caltrans extends this definition to include state-funded highway projects. The proposed project build alternative evaluated in this report is considered to be Type 1 because it would include the addition of an auxiliary lane and widen a ramp.

The following is a brief discussion of applicable federal and state regulations, standards, and policies:

National Environmental Policy Act (NEPA)

NEPA is a federal law that establishes environmental policy for the nation, provides an interdisciplinary framework for federal agencies to prevent environmental damage, and contains action-forcing procedures to ensure that federal agency decision makers take environmental factors into account. Under NEPA, impacts and measures to minimize adverse noise impacts must be identified, including the identification of impacts for which no abatement or only partial abatement is available.

Federal Highway Administration (FHWA) Regulations

Title 23, Part 772 of the Code of Federal Regulations (23 CFR 772) provides procedures for conducting highway-project noise studies and implementing noise abatement measures to help protect the public health and welfare, supply NAC, and establish requirements for information to be given to local officials for use in planning and designing highways. Under this regulation, noise abatement must be considered for a Type 1 project if the project is predicted to result in a traffic noise impact. A traffic noise impact is considered to occur when the project results in a substantial noise increase (defined as a 12 dBA increase or greater), or when the predicted noise levels approach or exceed NAC specified in the regulation. 23 CFR 772 does not specifically define what constitutes a substantial increase or the term approach; rather, it leaves interpretation of these terms to the states.

FHWA Regulations 772.11

Noise abatement measures that are reasonable and feasible and likely to be incorporated into the project shall be identified. Noise impacts for which no apparent solution is available shall also be identified. Table 4-1 summarizes the FHWA NAC.

TABLE 4-1 – NOISE ABATEMENT CRITERIA

Activity Category	Noise Abatement Criteria, $L_{eq(h)}$, dBA	Description of Activity Category
A	57 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 (Exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	--	Undeveloped lands
E	52 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

Source: 23 CFR Part 772, 2009

Notes:

1 – L_{eq}(h): 1-hour A-weighted equivalent sound level

2 – dBA: A-weighted decibels

Section 216 of the California Streets and Highways Code

Section 216 of the California Streets and Highways Code relates to the noise effects of a proposed freeway project on public and private elementary and secondary schools. Under this code, a noise impact occurs if, as a result of a proposed freeway project, noise levels exceed 52-dBA L_{eq}(h) in the interior of public or private elementary or secondary classrooms, libraries, multipurpose rooms, or spaces. This requirement does not replace the "approach or exceed" NAC criterion for FHWA Activity Category E for classroom interiors, but it is a requirement that must be addressed in addition to the requirements of 23 CFR 772.

If a project results in a noise impact under this code, noise abatement must be provided to reduce classroom noise to a level that is at or below 52-dBA L_{eq}(h). If the noise levels generated from freeway and non-freeway sources exceed 52-dBA L_{eq}(h) prior to the construction of the proposed freeway project, then noise abatement must be provided to reduce the noise to the level that existed prior to construction of the project.

5.0 STUDY METHOD AND PROCEDURES

This section describes the methods and procedures followed for the noise study, including the selection of representative sensitive receptor sites, noise measurement procedures, and traffic noise modeling required to conduct the analysis.

Selection of Sensitive Receptor Sites

Noise measurement sites are locations where noise measurements are taken in order to determine existing noise levels and to verify or calibrate computer noise models. These sites are chosen as being representative of similar sensitive sites in the area. Locations that are expected to receive the greatest noise impacts, such as the first row of houses from the noise source, are generally chosen. Noise measurements were also taken further back to respond to requests from the public during the scoping meeting. Noise measurements were conducted in frequent outdoor human-use areas. All measurement sites were selected so that there would be no interference from sources such as dogs, pool pumps, or children that could affect the measured levels. It is also desirable to choose sites that are free of major obstructions or contamination.

Noise Measurement Procedures

Noise measurements were conducted in conformance with the Caltrans' Technical Noise Supplement (Caltrans, 1998) and the guidelines outlined in the FHWA's "Measuring of Highway Related Noise," FHWA-DP-96-046. The following are brief descriptions of the measurement procedures used for this project:

- Microphones were placed approximately 1.5 meters (5 feet) above the ground and were positioned at least 3 meters (10 feet) from any wall or building to prevent reflections or unrepresentative shielding of the noise.
- Sound level meters were calibrated before and after each set of measurements.
- Following the calibration of equipment, a windscreen was placed over the microphone.
- Frequency weighting was set on "A", and the slow detector response was used.
- Results of the short-term noise measurements were recorded on data sheets in the field. Long-term measured data were downloaded to the computer for tabulation.
- During the short-term noise measurements, any noise contaminations such as barking dogs, local traffic, lawn mowers, etc. were noted.
- Traffic was counted for model calibration measurements. Vehicle types were separated into three vehicle groups: heavy trucks, medium trucks, and autos.
- Wind speed, temperature, humidity, and sky conditions were observed and documented during the short-term noise measurements.

The instruments used for the noise measurements included the following:

- Sound Level Meters – Larson Davis models 870 and 812 Integrating Sound Level Meters.
- Microphone Systems – LD 812 System: Larson Davis model PRM 828 microphone preamp; LD 870 System: Larson Davis model 900B and 900C microphone preamps; Larson Davis model 2559, ½-inch pressure microphone; Brüel & Kjær 4189 ½-inch pressure microphone.
- Acoustic Field Calibrator – Larson Davis model CA250 constant pressure microphone calibrator; Larson Davis model CAL200 constant pressure microphone calibrator.
- Wind Monitor/Temperature and Humidity Gauge – Kestrel 3000 Pocket Weather Meter.

School Interior and Exterior Noise Measurements

Simultaneous exterior and interior noise measurements for Carden School were conducted in conformance with Section N-3350, *Classroom Noise Measurements* in the Caltrans' Technical Noise Supplement (Caltrans, 1998) and the procedures outlined in *Building Noise Reduction Measurements in the Vicinity of a Highway* in FHWA's Measurement of Highway-Related Noise (FHWA, 1996). Microphones were located at the exterior and the interior of classrooms. Simultaneous noise measurements were conducted to estimate noise reduction provided by the building.

The instruments used for the noise measurements included the following:

- Real-Time Spectrum Analyzer (RTA) – LD model 2900 (Serial Numbers 0427 and 0484), two channel analyzers and Sound Level Meter with ANSI Type 1 accuracy.
- Microphone System – LD model PRM 900B microphone preamps, and LD model 2559, 1/2-inch random-incidence microphones.
- Acoustic Field Calibrator – Larson Davis model CA250 constant pressure microphone calibrator.

Traffic Noise Modeling

The FHWA Traffic Noise Model (TNM), Version 2.5, was used for the noise computations (FHWA, 2004). TNM 2.5 input is based on a three-dimensional grid created for the study area to be modeled. All roadway, barrier, terrain lines, and receiver points are defined by their x, y, and z coordinates. Roadways, terrain lines, and barriers are coded into TNM 2.5 as line segments defined by their end points. Receivers, defined as single points, are typically located at outdoor use area of the noise sensitive receptors such as residences, schools, and recreational areas. Receivers are modeled at a height of 5 feet (1.5 meters) above ground elevation.

In order to determine the noise levels generated by traffic, TNM 2.5 computer program requires inputs of traffic volumes, speeds, and vehicle types. Three vehicle types were input into the model: cars, medium trucks, and heavy trucks. The propagation path between source and receiver is modeled in TNM 2.5 by specifying special terrain features, rows of houses or building structures, and existing walls. Propagation of noise can be further specified by selecting ground types such as hard soil, loose soil, pavement, lawn, and field grass. Since ground between receptors and Highway 1 is heavily vegetated, a ground type of lawn was used for this study. Furthermore, "tree zones" ranging from 3.5 to 5.0 meters (11.5 to 16 feet) were used to simulate noise propagation through dense tree zones. All other natural obstructions, such as cuts and fills as well as safety barriers at the edge of the road that could affect the predicted noise levels were also included in the input files.

6.0 EXISTING NOISE ENVIRONMENT

Residential land uses are predominant along most of the Highway 1 project corridor between Soquel Drive and Morrissey Boulevard. Noise sensitive receptors that may be affected by the project include single- and multi-family residences, Harbor High School, Carden School, and Santa Cruz Community Church that are located in close proximity to the project corridor. Noise monitoring was conducted at various measurement sites that are representative of these sensitive receptors.

Noise measurements were taken at four locations within the Auxiliary Lanes Project limits in April of 2004 and one additional location in May of 2009. The additional measurement at ST26A was imperative because topographic features at residences near the northbound Soquel on-ramp are different than the adjacent long-term measurement site, LT10. ST26A does not have dense vegetation as LT10; therefore, estimation of the existing peak hour traffic noise level at ST26A using the measured data at LT10 could be much lower than the actual noise. The primary objectives of the measurements were for evaluating the existing noise environment and calibrating the noise prediction model. Short-term measurements were conducted at four sites for 20 minutes each, and a long-term measurement was conducted at one location for at least 24 hours.

As of February 2009, several soundwalls have been built along Highway 1 west of La Fonda Bridge as part of the State Route 1/State Route 17 Merge Lanes Project. This project was completed in the Fall of 2008. As a result, peak hour traffic noise levels at Receptors R7 through R13 and R21 through R27 behind these newly constructed soundwalls have changed since Year 2004 noise measurements. Therefore, existing noise levels behind these soundwalls were modeled using TNM.

Short-term measurements were conducted during time intervals outside of the peak noise hour. These measurements have been adjusted to reflect peak hourly noise levels using the results of the nearby long-term noise measurements. The peak noise hour was determined by a long-term measurement taken on the same day as each short-term measurement. The difference in noise levels between the hour in which the short-term level was recorded and the hour that the actual peak hour level occurred was then applied to each of the short-term levels to adjust it to the peak hour.

Results for the long-term and short-term measurements are presented in Table 6-1. Also included in the table is the land use type for each of the measurement sites. Appendix A includes noise measurement data sheets recorded in the field, as well as the hourly L_{eq} graph for the long-term measurement. Sheets 1 through 3 of Appendix B show the noise measurement sites as well as locations and heights of the newly constructed soundwalls.

Indoor/outdoor noise measurements were also conducted in Carden School to determine the building shell noise reduction. This school did not exist at the present location during 2004 noise measurements. Table 6-2 presents indoor/outdoor noise measurement results in Carden School. There are two buildings that are directly facing the highway. One building, represented by Receptor R6A-1, is currently used as a multi-purpose room where students have activities and afterschool programs. This building has single-pane aluminum slide windows and no air condition (A/C) unit. The other building, represented by Receptor R6A-2, is a modular classroom building that is equipped with separate wall-mounted A/C units and dual-pane windows. As summarized in Table 6-2, the classroom building and multi-purpose room provide 29.4 and 21.8 dB reduction, respectively. Graphs showing 1/3 octave spectrum curve between the exterior and interior traffic noise levels and the field note are included in Appendix D.

TABLE 6-1 – NOISE MEASUREMENT RESULTS

Site No.	Street Address, City	Land Use[1]	Noise Abatement Category (Criterion)[2]	Meter Location	Measurement Dates	Start Time	Measured L_{eq}, dBA[3,4]	Adjusted Peak-Hour L_{eq}, dBA[5]	Adjusted to Long-Term Site
LT10	152 Oak Way, Santa Cruz	SFR	B (67)	Back yard	04/26/04	15:15	65.0	--	--
LT11	339 Fairmount Ave, Santa Cruz	SFR	B (67)	Back yard	04/26/04	14:33	72.0	--	--
ST25	Harbor High School 300 La Fonda Ave, Santa Cruz	SCH	B (67)	Parking Lot	4/27/04	11:40	60.7	62.7	LT11[6]
ST26A	3059 Eleanor Way	MFR	B (67)	Driveway*	05/11/09	17:00	59.0	64.0	LT10
ST26	606 Trevethun Ave, Santa Cruz	SFR	B (67)	Side Yard	4/27/04	08:53	69.2	70.2	LT10
ST27	Santa Cruz Community Church Roxas St, Santa Cruz	CHR	B (67)	Parking Lot	4/27/04	10:47	71.4	73.4	LT11[6]

Source: Parsons

Notes:

1 – SFR - Single Family Residential; MFR - Multi-Family Residential; MOT - Motel/Hotel; SCH - School; CHR - Church.
2 – According to Caltrans Traffic Noise Analysis Protocol.
3 – All short-term measured noise levels are 20-minutes L_{eq}.
4 – The highest measured hourly noise level recorded during the long-term measurement period.
5 – Measurements conducted during off-peak hours were adjusted to the peak-hour L_{eq} based on a comparison with long-term noise levels which were measured at a nearby measurement site, listed in the last column.
6 – This measurement site is located outside of the project limits; however, hourly traffic noise distributions at LT11 are applicable to this project.
* – This measurement location is acoustically equivalent to the patio of this receptor; thus, it is representative of the outdoor use area.
LT – long-term noise measurement site, ST – short-term measurement site.

TABLE 6-2 – CARDEN SCHOOL INDOOR/OUTDOOR NOISE MEASUREMENT RESULTS

Measurement Location	Exterior Noise Levels, dBA[1]		Interior Noise Levels, dBA[1]		Noise Reduction, dB	
	window/closed	window/open	window/closed	window/open	window/closed	window/open
Classroom D	70.6	70.1	41.2	61.5	29.4	8.6
Multi-purpose Room	71.4	71.5	49.6	64.0	21.8	7.5

Notes:
1 – Noise Levels are A-weighted and time average sound in decibels.

Model Calibration

A noise measurement for the calibration was conducted at one of the short-term measurement sites with simultaneous traffic counts in April 2004. The second set of calibration measurements were conducted in April 2009 behind one of the newly constructed soundwalls. During the measurement, traffic volumes on Highway 1 were concurrently recorded. The traffic counts were tabulated according to three vehicle types, including automobiles, medium trucks (2-axle with 6-wheels but not including dual axle pick-up trucks), and heavy trucks (3 or more axle vehicles). The field observations and measured data were used to calibrate the traffic noise model.

According to the California Department of Transportation's (Caltrans) Technical Noise Supplement, given the inherent uncertainties in the measurements and calibration procedures, use of a calibration factor should not be included when calculated and measured noise levels agree within ±2 dB.

Table 6-3 presents the result of the model calibration along with the traffic counts taken during the calibration measurement. The modeled noise level at the calibration location was higher than the measured noise levels at the calibration location. Heavy vegetation along Highway 1 appears to be providing some noise attenuation between roadways and receptors. Since the deviation at the calibration site was within 2 dB difference, no calibration factor was applied to the modeling.

TABLE 6-3 – NOISE MODEL CALIBRATION

Measurement Site	Direction	Hourly Traffic Volumes				Operating Speed, km/h (mph)	Calibration Result Summary			
		Total Hourly Volume	Cars Vol (%)	Medium Trucks Vol (%)	Heavy Trucks Vol (%)		Noise Levels, $L_{eq(h)}$, dBA		Deviation, dB	Applied Adjustment, dB
							Measured	Modeled		
Cal 8/ST26	NB	3879	3648 (94.0)	165 (4.3)	66 (1.7)	105 (65)	69.2	70.4	1.2	0.0
	SB	3636	3462 (95.2)	159 (4.4)	15 (0.4)	105 (65)				

Source: Parsons.
Note: CALx – calibration sites; STxx – short-term measurement sites.

7.0 FUTURE NOISE ENVIRONMENT, IMPACTS, AND CONSIDERED ABATEMENT

The noise study was conducted to assess potential future noise impacts at sensitive receptors within the limits of the project. The future worst case scenario traffic noise levels were modeled to evaluate the appropriate abatement measures. This section discusses the future noise environment and considers possible abatement measures for impacted locations.

7.1 TRAFFIC DATA

The worst-case traffic noise occurs when traffic is operating under Level-of-Service C (LOS C) conditions. Under LOS C conditions, traffic is heavy, but remains free flowing. LOS C volume of 1,800 vehicles-per-hour (vph) per lane was utilized in modeling Highway 1 mainline traffic volumes, and LOS C volume of 1,500 vph for auxiliary lanes. Year 2015 ramp traffic volumes were compared to the LOS C volume of 1,000 vph per lane, and the lesser of the two was used in modeling ramp traffic. Traffic volumes on the auxiliary lanes were separated from the mainline for the purpose of more accurate traffic noise modeling.

Tables 7-1 and 7-2 present traffic volumes and traffic distributions per direction of travel for No-Build conditions (existing and future No-Build) and for the Auxiliary Lanes Alternative (future Build), respectively. These traffic volumes and distributions were used as roadway input parameters for TNM. According to the Traffic Operations Report (Caltrans, 2008), existing mainline traffic volumes are already exceeding the LOS C volume of 1,800 vph per lane; thus, the mainline traffic used in TNM is capped at the LOS C volume of 1,800 vph per lane. Mainline traffic volumes for Future No-Build would also exceed the LOS C volume of 1,800 vph per lane. Therefore, vehicle volumes and distributions during peak traffic noise hours between the existing and future No-Build are identical in most of the mainline segments.

Since the highway traffic would be the dominant noise source at a majority of the receptors located adjacent to the project corridor, no local surface street traffic was modeled.

The operating speed of 105 km/h (65 mph) was used for mainline lanes and auxiliary lanes. For ramps, gradually varying speeds from 40 to 105 km/h (25 to 65 mph) were used in TNM. Truck percentages for mainlines and ramps for both alternatives were obtained from the Traffic Operations Report for this project. Truck percentages for auxiliary lanes were estimated by averaging truck percentages between on- and off-ramps.

TABLE 7-1 – TRAFFIC VOLUMES USED IN TNM MODELING EXISTING AND FUTURE NO-BUILD

Existing

Mainline Segments		Number of Lane	Total	Cars	MT	HT	Truck %
NORTHBOUND							
Soquel Dr Off-/On-ramp	Mainlines	2	3627	3402	148	77	6.2%
Soquel Dr to Morrissey Blvd	Mainlines	2	3600 [1]	3373	149	78	6.3%
Morrissey Blvd Off-/On-ramp	Mainlines	2	3600 [1]	3348	166	86	7.0%
West of Morrissey Blvd	Mainlines	2	3600 [1]	3362	156	81	6.6%
Soquel Ave On-Ramp	Ramp	1	452	417	23	12	7.8%
Morrissey Blvd Off-Ramp	Ramp	1	664	641	15	8	3.5%
Morrissey Blvd On-Ramp	Ramp	1	358	349	6	3	2.4%
SOUTHBOUND							
Soquel Dr On-/Off-ramp	Mainlines	2	2902	2792	72	38	3.8%
Soquel Dr to Morrissey Blvd East of La Fonda Ave	Mainlines	2	3600 [1]	3438	106	56	4.5%
Soquel Dr to Morrissey Blvd West of La Fonda Ave	Mainlines	2	2710	2588	80	42	4.5%
	Auxiliary	1	1129	1100	19	10	2.6%
Morrissey Ave On-/Off-ramp	Mainlines	2	2395	2304	60	31	3.8%
	Auxiliary	1	998	985	8	4	1.3%
Soquel Off-Ramp	Ramp	1	937	898	26	13	4.2%
Morrissey On-Ramp	Ramp	1	446	441	3	2	1.0%

Future No-Build

Mainline Segments		Number of Lane	Total	Cars	MT	HT	Truck %
NORTHBOUND							
Soquel Dr Off-/On-ramp	Mainlines	2	3295	3091	134	70	6.2%
Soquel Dr to Morrissey Blvd	Mainlines	2	3600 [1]	3373	149	78	6.3%
Morrissey Blvd Off-/On-ramp	Mainlines	2	3600 [1]	3348	166	86	7.0%
West of Morrissey Blvd	Mainlines	2	3600 [1]	3362	156	81	6.6%
Soquel Ave On-Ramp	Ramp	1	952	878	49	25	7.8%
Morrissey Blvd Off-Ramp	Ramp	1	828	799	19	10	3.5%
Morrissey Blvd On-Ramp	Ramp	1	497	485	8	4	2.4%
SOUTHBOUND							
Soquel Dr On-/Off-ramp	Mainlines	2	3228	3105	81	42	3.8%
Soquel Dr to Morrissey Blvd East of La Fonda Ave	Mainlines	2	3600 [1]	3438	106	56	4.5%
Soquel Dr to Morrissey Blvd West of La Fonda Ave	Mainlines	2	3003	2868	89	46	4.5%
	Auxiliary	1	1251	1219	21	11	2.6%
Morrissey Ave On-/Off-ramp	Mainlines	2	2580	2482	64	34	3.8%
	Auxiliary	1	1075	1062	9	5	1.3%
Soquel Off-Ramp	Ramp	1	1000 [1]	958	28	14	4.2%
Morrissey On-Ramp	Ramp	1	599	593	4	2	1.0%

Note:

1 - The projected traffic volume would exceed the LOS C volume in this segment; thus, the volume was capped at the LOS C volume.

Source: Traffic Operations Report (Caltrans, 2008)

TABLE 7-2 – TRAFFIC VOLUMES USED IN TNM MODELING FUTURE BUILD

Mainline Segments		**Number of Lane**	**Total**	**Cars**	**MT**	**HT**	**Truck %**
NORTHBOUND							
Soquel Dr Off-/On-ramp	Mainlines	2	3600	3377	147	77	6.2%
Soquel Dr to Morrissey Blvd	Mainlines	2	3600	3373	149	78	6.3%
	Auxiliary	1	1500	1415	56	29	5.7%
Morrissey Blvd Off-/On-ramp	Mainlines	2	3600	3348	166	86	7.0%
West of Morrissey Blvd	Mainlines	2	3600	3362	156	81	6.6%
Soquel Ave On-Ramp	Ramp	1	980	904	50	26	7.8%
Morrissey Blvd Off-Ramp	Ramp	1	841	812	19	10	3.5%
Morrissey Blvd On-Ramp	Ramp	1	497	485	8	4	2.4%
SOUTHBOUND							
Soquel Dr On-/Off-ramp	Mainlines	2	3600	3463	90	47	3.8%
Soquel Dr to Morrissey Blvd	Mainlines	2	3600	3438	106	56	4.5%
	Auxiliary	1	1500	1461	26	13	2.6%
Fairmount Ave On-/Off-ramp	Mainlines	2	3600	3463	90	47	3.8%
West of Fairmount Ave	Mainlines	1	1500	3460	92	48	3.9%
Soquel Off-Ramp	Ramp	1	1000	958	28	14	4.2%
Morrissey On-Ramp	Ramp	1	658	652	4	2	1.0%
Fairmount Ave Off-Ramp	Ramp	1	385	379	4	2	1.5%

Source: Traffic Operations Report (Caltrans, 2008)

7.2 NOISE IMPACT AND BARRIER ANALYSIS

The predicted peak-hour noise levels for the No-Build and Build Alternatives are presented in this section. In this analysis, the No-Build Alternative incorporates recently reconfigured roadway geometry and soundwalls that were built as part of the State Route 1/State Route 17 Merge Lanes Project. An analysis with barrier heights ranging from 8 feet (2.4 meters) to 16 feet (4.9 meters) was conducted for impacted noise sensitive areas. All recommended barrier heights and locations are designed to provide a minimum of 5-dB noise reduction.

An important height consideration in recommending soundwalls is the Caltrans' requirement to break the line of sight (Highway Design Manual, Chapter 1100). This requirement was intended to lessen the visual and noise intrusiveness of truck exhaust stacks at the first row receiver(s). Various heights were evaluated through calculations performed by TNM 2.5. The minimum barrier heights required to cut the line of sight from each receptor to the exhaust stacks of heavy trucks have been calculated for all recommended barriers.

Table 7-3 presents the results of the barrier analysis for the Build Alternative. Table 7-4 provides the summary of feasible barriers, including the number of benefited residences, reasonable allowance per residence, and reasonable allowance cost per barrier. Table 7-5 presents summaries of barrier location, elevation, and length. The recommended soundwalls locations (i.e. right-of-way line or shoulder) are modeled to provide the greatest barrier attenuation within the right-of-way limits. The heights and locations of the feasible soundwalls are also shown graphically on the figures in Appendix B. Worksheets A and B of the cost analysis are included in Appendix C. There are also two existing soundwalls in the study area that were constructed as part of the State Route 1/State Route 17 Merge Lanes Project.

Noise impacts are identified for frequent outdoor human use areas of almost all the benefited residences along the project corridor. The Computer Noise Modeling Input/Output files for calibration and the Build Alternative are included in Appendix E.

Future build traffic noise levels were modeled using the level of service (LOS) C traffic volumes for Highway 1 and Year 2015 peak hour traffic volumes on the ramps to obtain the worst-case noise scenario. Soundwall heights between 8 feet (2.4 meters) and 16 feet (4.9 meters) were considered to abate the predicted traffic noise impacts at the frequent outdoor human use areas of residences and a church within the proposed project area. The recommended noise barriers were designed to reduce traffic noise levels by at least 5 dB, the minimum requirement of soundwall attenuation. In addition, the recommended wall heights are designed to block the line-of-sight to heavy truck exhaust stacks.

Overall, peak hour traffic noise levels for the Build Alternative are within 2-dB from the No-Build Alternative. When modeled peak hour noise levels for the Build Alternative are compared to the existing levels, differences are limited to 2-dB except for Receptors R16 through R20. In regards to Receptors R16 through R20, the difference reaches up to 9-dB between the Existing and the Build Alternative. The difference of 9-dB is because of the existing noise level estimation methodology for these receptors based upon the measured noise level at R17.

Receptor R17 is a long-term measurement site, representing Receptors R16, R18, R19, and R20. Considering their distance from Highway 1 and the topography, these receptors are acoustically equivalent. Therefore, the difference in peak hour noise levels between the future No-Build Alternative and the Existing was applied to Receptors R16, R18, R19, and R20 to estimate the existing noise levels. During the site visit, dense vegetation was observed between Receptor R17 and the edge of Highway 1. Due to the wood fence at the property line, there was no access to the vegetated area to verify and investigate terrain features that might have been providing substantial noise reduction for this receptor. Therefore, it was assumed that there were no obstructive terrain features between the receptor and the highway in TNM. This would ensure a more conservative approach in predicting the No-Build and Build Alternatives.

The interior noise levels of Carden School classrooms and a multi-purpose room were modeled using TNM and incorporating the measured building noise reductions. The future peak hour interior noise level in classrooms of a modular building would be below the interior noise criterion of 52 dBA with windows closed, and these rooms are equipped with separate wall-mounted A/C units. Whereas, the future peak hour interior noise level in the multi-purpose room would exceed the 52 dBA criterion. This is because this building has single-pane aluminum slide windows. In a typical modular building, windows are the weakest link because they allow more noise to be transmitted into the building than composite siding walls or solid doors.

Peak hour traffic noise levels at 43 single-family residences as well as outdoor use areas of Carden School and Santa Cruz Community Church along Highway 1 within the project limits would approach or exceed the Noise Abatement Criteria. Six soundwalls on Highway 1 shoulders or on the right-of-way lines in both direction of travel would be feasible with a total combined length of 3,505 feet (1,068 meters). The feasible soundwalls would benefit a total of 31 single-family residences and Carden School of Santa Cruz (3 frontage units). The future peak hour noise level at the sensitive outdoor use area of Harbor High School would be below the NAC (for category B); thus, no abatement measure would be necessary.

Areas with noise abatement

Soundwall S172: Soundwall S172 is located on the northbound side of the freeway east of La Fonda Avenue on the right-of-way line. This 8 to 10-foot high soundwall would provide feasible abatement for 12 single-family residences represented by Receptors R17 and R18. There is a low right-of-way elevation point near Sta. 172+90; therefore, a portion of this soundwall will be located on top of a retaining wall. Sheets 2 and 3 in Appendix B show the location of this soundwall.

Soundwalls S176 and S178: Soundwalls S176 and S178 are located on the northbound side of the freeway and west of La Fonda Avenue. Soundwall S176 would start on the right-of-way line at Sta. 174+35, transition to 7 feet north of the shoulder of Highway 1 northbound from Sta. 175+40, and terminate at Sta. 176+90. This soundwall alone would provide feasible abatement for 13 single-family residences located on Holway Drive and Morrissey Boulevard that are represented by Receptors R19 and R20.

Two house on Morrissey Boulevard represented by Receptor R21 have an existing 10-foot (3.0-meter) high soundwall. Replacing a portion of the existing wall that is behind these two houses with 14-foot high Soundwall 178, combined with 14-feet (4.7-meter) high Soundwall S176, would provide an additional 5-dB noise reduction for these two single-family residences. However, if only Soundwall S176 is constructed, then these two houses would not receive the additional 5-dB noise reduction. Sheet 3 in Appendix B shows the location of these two soundwalls.

Soundwall S173: Soundwall S173 is located on the southbound side of the freeway and on the right-of-way line just east of La Fonda Avenue. This soundwall would provide feasible abatement for one single-family residence represented by Receptor R3. Sheets 1 and 2 in Appendix B show the location of this soundwall.

Soundwall S175: Soundwall S175 is located on the southbound side of the freeway and on the right-of-way line just west of La Fonda Avenue. This soundwall would provide feasible abatement for one severely impacted single-family residence represented by Receptor R5. Because the future predicted traffic noise levels at the outdoor use area of this house would be over 75 dBA, "unusual and extraordinary" abatement measures must be considered. This means that a soundwall can be constructed even if the cost exceeds the reasonableness allowance or building acoustical treatment must be considered if Soundwall S175 cannot be constructed. Sheet 2 in Appendix B shows the location of this soundwall.

Soundwall S177: Soundwall S177 located on the southbound side of the freeway along the shoulder of Highway 1 southbound and west of La Fonda Avenue. The height of this soundwall would be 14 feet (4.3 meters), and it must tie into the existing 12-foot (3.7-meter) high soundwall on the west. This extension would provide feasible abatement for two single-family residences on Parkway Court and an outdoor use area of Carden School of Santa Cruz that are represented by Receptors R6 and R6B, respectively. This soundwall would also benefit the interior of classrooms, Receptor R6A-1, and a multi-purpose building, Receptor R6A-2. Sheet 2 in Appendix B shows the location of this soundwall, residences, and the school.

If Soundwall S177 is determined to be unreasonable, then acoustical treatment would be required for the multi-purpose room because the predicted future traffic noise level would be over 75 dBA which means this area is severely impacted. In this case, installation of dual-pane windows with a minimum Sound Transmission Class (STC) rating of 32 should provide noise abatement for the interior of the multi-purpose room. An STC rating is commonly used by various window manufacturers to specify acoustical noise reduction by windows. A building with STC-32 rated windows generally provide a 30-dB reduction between the exterior and interior noise levels. Additionally, this room would need an A/C unit to provide climate control when windows are closed.

Areas without noise abatement

There would be 12 residences and an outdoor use area of Santa Cruz Community Church in the study area with the future predicted traffic noise levels approaching or exceeding the NAC but without feasible abatement. This is because a soundwall would not be feasible or a soundwall cannot be constructed due to the topography or other futures. The following is an explanation of these areas:

Receptors R7, R8, and R22: Future peak hour noise levels at most of the residences behind the existing soundwalls between La Fonda Avenue and Morrissey Boulevard would not approach or exceed the NAC of 67 dBA. However, future peak hour noise levels at three single-family residences located on the northbound side of the freeway on Morrissey Boulevard represented by Receptor R22, three single-family residences located on the southbound side of the freeway on Parkway Court represented by Receptor R7, and Santa Cruz Community Church located on the southbound side of the freeway represented by Receptor R8 would exceed the NAC in the future, even with the existing soundwalls in the range of 10 feet (3.0 meters) and 16 feet (4.9 meters). These two existing soundwalls in the study area were constructed as part of the State Route 1/ State Route 17 Merge Lanes Project, and they are shown on Sheets 2 and 3 in Appendix B. Neither raising the existing soundwalls up to 16 feet (4.9 meters) nor extending them would provide the additional 5-dB reduction. Thus, no further abatement measures would be feasible. Sheet 2 in Appendix B shows the location of these houses and the church.

ReceptorR15: Two single-family residences represented by Receptor R15 which are located on the northbound side of the freeway west of Paul Sweet Drive on Eleanor Way would have future predicted traffic noise levels, exceeding the NAC. Due to steep downward slope and a deck overlooking the freeway, a soundwall would not be feasible or practical without cutting through private properties. Sheet 1 in Appendix B shows the location of these houses.

Receptor R16: Four single-family residences located on the northbound side of the freeway on Oak Way just east of Fairland Way represented by Receptor R16 have steep downward slope or multi-tiered yards with a view of Highway 1. Therefore, a soundwall would not be effective in providing feasible abatement for these houses. Sheet 1 in Appendix B shows the location of these houses.

TABLE 7-3 – FUTURE NOISE LEVELS AND BARRIER ANALYSIS

REC. NO.	LAND USE[2]	EXISTING NOISE LEVELS[1, 3] Leq(h), dBA	FUTURE PEAK HOUR NOISE LEVELS, Leq(h), dBA[1, 6] FUTURE NO BUILD	PROJECT "BUILD" WITHOUT BARRIER	ACTIVITY CATEGORY and NAC ( )	IMPACT TYPE (S, A/E or NONE)[4]	NOISE PREDICTION WITH BARRIER AND BARRIER INSERTION LOSS (I.L.) 8 ft (2.4 m) Leq(h)	8 ft (2.4 m) I.L.	10 ft (3.0 m) Leq(h)	10 ft (3.0 m) I.L.	12 ft (3.7 m) Leq(h)	12 ft (3.7 m) I.L.	14 ft (4.3 m) Leq(h)	14 ft (4.3 m) I.L.	16 ft (4.9 m) Leq(h)	16 ft (4.9 m) I.L.	BARRIER NO./LOCATION
R 1	MFR	62 [E]	62	63	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	--
R 2	SCH	63 [M,ST25]	63	64	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	
R 3[C]	SFR	66 [E]	66	68	B (67)	A/E	65	3	65 [T]	3	64	4	64	4	**63** [R]	5	S173 / R/W
R 4	SFR	59 [E]	59	61	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	
R 5[C]	SFR	75 [E]	75	77	B (67)	A/E	68	9	**65** [T,R]	12	65	12	63	14	63	14	S175 / R/W
R 6A-1	SCH	53 [E]	53	54	E (52)	A/E	50	4	49	5	48	6	47 [5]	7	47	7	S177 / Shoulder
R 6A-1*	SCH	75 [E]	75	76	B (67)	A/E	72	4	71	5	70	6	69 [5]	7	69	7	
R 6A-2	SCH	44 [E]	44	45	E (52)	NONE	39	6	38	7	37	8	35 [5]	10	34	11	
R 6B	SCH	69	69	70	B (67)	A/E	65	5	64	6	64	6	**61** [T,R]	9	61	9	
R 6[C]	SFR	71 [E]	71	71	B (67)	A/E	65	6	64	7	62 [T]	9	**61** [R,5]	10	61	10	
R 7[W]	SFR	68 [E,N]	69	69	B (67)	A/E	--	--	--	--	--	--	65	4	65	4	
R 8[W]	CHR	67 [M,ST27,N]	67	68	B (67)	A/E	--	--	--	--	--	--	65	3	65	3	
R 9[W]	SFR	63 [N]	63	64	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	--
R 10[W]	SFR	63 [N]	63	64	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	
R 11[W]	SFR	61 [N]	62	62	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	
R 12[W]	SFR	62 [N]	62	63	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	
R 13[W]	SFR	59 [N]	59	60	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	
R 14	MFR	64 [M.ST26A]	65	65	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	R/W
R 15	SFR	65 [E]	66	67	B (67)	A/E	66	1	65	2	65	2	65	2	65	2	
R 16	SFR	71 [E]	71	72	B (67)	A/E	--	--	--	--	--	--	--	--	--	--	S172 / R/W
R 17	SFR	72 [E,M,LT10]	72	74	B (67)	A/E	**67** [T,R]	7	66	8	65	9	63	11	63	11	
R 18[C]	SFR	75 [E]	75	76	B (67)	A/E	67	9	**66** [T,R]	10	65	11	64	12	63	13	
R 19	SFR	77 [E]	77	78	B (67)	A/E	72	6	**69** [T,R]	9	67	11	66	12	61	17	S176 & S178 R/W & Shoulder
R 20[C]	SFR	73 [E]	73	74	B (67)	A/E	66	8	65	9	63 [T]	11	**62** [R,5]	12	61	13	
R 21[C,W]	SFR	66 [N]	66	68	B (67)	A/E	--	--	--	--	65 [T]	3	**63** [R]	5	62	6	
R 22[W]	SFR	67 [N]	67	68	B (67)	A/E	--	--	--	--	--	--	67	1	66	2	
R 23[W]	SFR	62 [N,ST26,CAL8]	62	63	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	--
R 24[W]	SFR	64 [N]	64	65	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	
R 25[W]	SFR	62 [N]	63	63	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	
R 26[W]	SFR	63 [N]	63	63	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	
R 27[W]	SFR	64 [N]	64	65	B (67)	NONE	--	--	--	--	--	--	--	--	--	--	

Notes:

1 - Leq(h) are A-weighted, peak hour noise levels in decibels.
2 - Land Use: SFR - single-family residence; MFR - multi-family residence; SCH - School; CHR - Church.
3 - M - Measured noise level; STxx or LTxx - measurement site number; E - Estimated using future "Build" and measured data; CALxx - calibration site.
4 - S = Substantial Increase (12 dBA or more); A/E = Approach or exceed NAC.
5 - Barrier height recommended to meet requirements at adjacent receptor(s).
6 - Traffic noise from the freeway only; other local noise sources are not included.
* - This modeling point is the exterior of a multi-purpose room; there is no outdoor human use at this location.
C - Critical design receiver.
R - Recommended height to meet feasibility requirements of Department's Noise Abatement Protocol.
T - Minimum height required to block the line-of-sight from the receptor to truck exhaust stacks.
W - This receptor receives traffic noise reduction from a new soundwall as part of State Route 1 and State Route 17 Merge Lanes Project.
N - The existing noise level herein is modeled using TNM because of the changes in roadway reconfiguration and the addition of soundwalls since 2004 measurement event. These geometrical changes are due to State Route 1 and State Route 17 Merge Lanes Project.

TABLE 7-4 – SUMMARY OF FEASIBLE BARRIERS

Barrier No.	Receptor No.	Type[1] and No. of Benefited Residences	Barrier Location/ Hwy. Side	Barrier Height/Total Length, ft (m)	Reasonable Cost per Residence	Reasonable Allowance Cost Per Barrier	Estimated Construction Cost
S172	R17, R18	12 SFR	R/W Northbound	8 ft (2.4 m) to 10 ft (3.0 m) / 822 ft (250 m)	$60,000	$720,000	$297,780
S173	R3	1 SFR	R/W Southbound	16 ft (4.9 m) / 417 ft (127 m)	$48,000	$48,000	$248,920
S175	R5	1 SFR	R/W Southbound	10 ft (3.0 m) / 247 ft (75 m)	$58,000	$58,000	$76,880
S176	R19, R20	13 SFR	R/W / Shoulder Northbound	10 ft (3.0 m) and 14 ft (4.3 m) / 857 ft (261 m)	$58,000	$754,000	$373,800
S178	R21	2 SFR	R/W Northbound	14 ft (4.3 m) / 255 ft (78 m)	$52,000	$104,000	$129,000
S177	R6A to R6	2 SFR 1 SCH (3 frontage units)	Shoulder Southbound	14 ft (4.3 m) / 907 ft (276 m)	$44,000	$220,000	$481,600

Notes:
1. Land Use: SFR - single-family residence; SCH - school.

TABLE 7-5 – BARRIER LOCATIONS AND ELEVATIONS

Barrier No.	Receptor No.	Type[1] and No. of Benefited Residences	Barrier Location	HWY 1 Barrier Station	Barrier Height, ft (m)	Top of Barrier Elevation, ft (m)[2]
S172	R17, R18	12 SFR	R/W	171+73	8 (2.4)	103.2 (31.4)
				171+92	8 (2.4)	107.1 (32.6)
				172+07	8 (2.4)	108.1 (32.9)
				172+37	8 (2.4)	106.4 (32.4)
				172+69	8 (2.4)	103.5 (31.5)
				172+78	8 (2.4)*	98.4 (30.0)
				172+88	8 (2.4)*	98.4 (30.0)
				172+95	8 (2.4)*	98.4 (30.0)
				173+04	8 (2.4)*	98.4 (30.0)
				173+51	10 (3.1)	105.2 (32.1)
				173+90	10 (3.1)	110.1 (33.6)
				174+19	10 (3.1)	110.1 (33.6)
			Approximate Length: 822 ft (250 m)			
S173	R3	1 SFR	R/W	173+02	16 (4.9)	86.6 (26.4)
				173+19	16 (4.9)	89.8 (27.4)
				173+49	16 (4.9)	99.7 (30.4)
				173+96	16 (4.9)	104.6 (31.9)
				174+29	16 (4.9)	111.2 (33.9)
			Approximate Length: 417 ft (127 m)			
S175	R5	1 SFR	R/W	174+51	10 (3.1)	105.2 (32.1)
				174+78	10 (3.1)	102.9 (31.4)
				175+06	10 (3.1)	100.9 (30.8)
				175+12	10 (3.1)	100.2 (30.6)
				175+13	10 (3.1)	101.9 (31.1)
			Approximate Length: 247 ft (75 m)			
S176	R19, R20	13 SFR	Shoulder / R/W	174+35	10 (3.1)	106.8 (32.6)
				174+53	10 (3.1)	105.2 (32.1)
				174+71	10 (3.1)	103.5 (31.6)
				175+20	10 (3.1)	101.9 (31.1)
				175+40	10 (3.1)	98.6 (30.1)
				175+70	10 (3.1)	90.4 (27.6)
				175+70	14 (4.3)	94.4 (28.8)
				175+97	14 (4.3)	94.4 (28.8)
				176+48	14 (4.3)	96.0 (29.3)
				176+90	14 (4.3)	96.0 (29.3)
			Approximate Length: 857 ft (261 m)			
S178	R19, R20	2 SFR	R/W	176+41	14 (4.3)	101.6 (31.0)
				176+55	14 (4.3)	103.3 (31.5)
				176+55	14 (4.3)	100.6 (30.7)
				176+70	14 (4.3)	101.9 (31.1)
				176+70	14 (4.3)	104.2 (31.8)
				177+16	14 (4.3)	107.5 (32.8)
			Approximate Length: 255 ft (78 m)			
S177	R6A to R6	2 SFR 1 SCH (3 frontage units)	Shoulder	175+25	14 (4.3)	92.1 (28.1)
				175+50	14 (4.3)	92.8 (28.3)
				176+00	14 (4.3)	94.1 (28.7)
				176+37	14 (4.3)	94.7 (28.9)
				176+37	14 (4.3)	94.7 (28.9)
				176+50	14 (4.3)	95.4 (29.1)
				177+00	14 (4.3)	98.3 (30.0)
				177+65	14 (4.3)	102.6 (31.3)
				178+00	14 (4.3)	105.2 (32.1)
			Approximate Length: 907 ft (276 m)			

Note:
1 - Land Use: SFR - single-family residence; SCH - school.
2 - Top of barrier elevations take precedence over the recommended barrier height. Therefore, the barrier shall be constructed according to the top-of-barrier elevations as listed in this table.
* - This wall will be on top of a retaining wall; therefore, the wall height could vary based on the retaining wall design.

8.0 CONSTRUCTION NOISE

The construction of the proposed project would take approximately 18-24 months, commencing in early 2010. Proposed construction activities would include roadway clearing, roadway pavement/stripping, and La Fonda Bridge demolition/reconstruction to accommodate space for the auxiliary lane. During the proposed construction phases, noise from construction activities may intermittently dominate the noise environment in the immediate area of construction. Construction noise is regulated by the Caltrans' Standard Specifications, May 2006, Section 7-1.01I, Sound Control Requirements. These requirements state that noise levels generated during construction shall comply with applicable local, state, and federal regulations and that all equipment shall be fitted with adequate mufflers according to the manufacturers' specifications.

The proposed project would temporarily affect sensitive receptors along Highway 1 within the City of Santa Cruz and the unincorporated part of Santa Cruz County known as Soquel. Neither jurisdiction imposes any quantifiable construction noise limits; however, they provide construction noise curfews. The County prohibits any offensive noise, including construction, between 10:00 p.m. and 8:00 a.m. within one hundred feet of any building or place regularly used for sleeping purposes (Santa Cruz County, 1989). The construction hour restriction by the City of Santa Cruz is the same as the County, but the City allows the commencement of construction at 7:00 a.m. for public works contracts awarded by the City of Santa Cruz with the approval of the director of public works (Santa Cruz, 2007).

Noise impacts from construction activities are a function of the noise generated by construction equipment, the location, the sensitivity of nearby land uses, as well as the timing and duration of the noise generating activities. Normally, construction activities are carried out in stages and each stage has its own noise characteristics based on the mix of construction equipment in use. The noise levels created by construction equipment will vary greatly depending on factors such as the type of equipment, the specific model, the operation being performed, and the condition of the equipment. Construction activity noise levels also depend on the fraction of time that the equipment is operated, known as the equipment usage rate. Overall, construction noise levels are normally governed primarily by the noisiest piece of equipment.

Table 8-1 summarizes noise levels produced by construction equipment commonly used on roadway construction projects. As indicated, equipment involved in construction is expected to generate noise levels ranging from 74 to 101 dBA at a distance of 50 feet (15 meters). Noise produced by construction equipment would be reduced over distance at a rate of about 6 to 7.5 dB per doubling of distance depending on the intervening topography and ground cover. Roadway clearing and Roadway pavement/stripping would utilize various pieces of equipment such as front end loaders, backhoes, and asphalt pavers/rollers. During the bridge demo/reconstruction, heavier duty equipment such as pile drivers or auger drill rigs may be utilized. The exact pile installation method for the bridge demo/construction has not been finalized as of the date of this report. Noise levels can vary substantially depending on the type of pile installation method implemented such as impact pile driving, vibratory pile driving and/or cast-in-drilled-hole (CIDH) piling. As shown in Table 8-1, the difference between impact pile driving and CIDH piling using auger drill rig can be as much as 15 dB measured at 50 feet (15 meters) from the equipment.

Temporary construction noise impacts would be unavoidable during La Fonda Avenue Bridge demolition/reconstruction. Four single-family residences that are adjacent to the bridge on both sides of the freeway would potentially be subject to temporary construction noise impacts.

TABLE 8-1 – CONSTRUCTION EQUIPMENT NOISE

Type of Equipment	Maximum Noise Level, dBA at 50 feet (15 meters)
Auger Drill Rig	86
Asphalt Paver	89
Asphalt Roller	78
Backhoe	75
Compactor	76
Concrete Pump	81
Crane	85
Dozer	85
Excavator	83
Front End Loader	74
Grader	75
Heavy Duty Dump Trucks	77
Vibratory Roller	78
Pavement Breaker	88
Pile Driver, Impact	101
Pile Driver, Vibratory	96

Source: Parsons

Caltrans Standard Specifications Section 7-1.1011 requires the following mandatory noise abatement measures:

- The Contractor shall comply with all local sound control and noise level rules, regulations, and ordinances which apply to any work performed pursuant to the contract.
- Each internal combustion engine, used for any purpose on the job, or related to the job, shall be equipped with a muffler of a type recommended by the manufacturer. No internal combustion engine shall be operated on the job site without an appropriate muffler.

In addition to the abatement measures listed above, implementing the following recommended measures would minimize temporary construction noise impacts:

- Minimize construction activities at residential areas during evening, nighttime, weekend, and holiday periods. Noise impacts are typically minimized when construction activities are performed during daytime hours (between 8:00 a.m. and 9:00 p.m.). However, nighttime construction may be desirable (e.g. in commercial areas where businesses may be disrupted during daytime hours) or necessary to avoid major traffic disruption.
- If possible, avoid using impact pile driving for bridge demo/reconstruction. Utilize less noise intrusive pile installation techniques such as vibratory pile driving or CIDH piling.
- In case of construction noise complaints by the public, the construction manager shall be notified and the specific noise producing activity may be changed, altered, or temporarily suspended if necessary. Consult district noise staff if especially egregious noise producing activities can not be reduced in the field.
- All equipment shall have sound-control devices no less effective than those provided on the original equipment. No equipment shall have an unmuffled exhaust.
- Plan to conduct truck loading, unloading and hauling operations so that noise is kept to a minimum by carefully selecting routes to avoid going through residential neighborhoods to the greatest possible extent.
- Use and relocate temporary barriers, if need, to protect sensitive receptors from excessive construction noise generated by small items such as compressors, generators, pneumatic tools, and jackhammers. Noise barriers can be made of heavy plywood, moveable insulated sound blankets, or other best available control techniques.
- As directed by the Caltrans' resident engineer, the contractor shall implement appropriate additional noise abatement measures including, but not limited to, changing the location of stationary construction equipment, turning off idling equipment, rescheduling construction activity, notifying adjacent residents in advance of construction work, or installing acoustic barriers around stationary construction noise sources.
- When it would not interfere with other construction activities, construct recommended permanent soundwalls during the first phase of construction to protect sensitive receptors from subsequent construction noise, dust, light, glare, etc.

Vibration Discussion

Buildings founded on the soil in the vicinity of the construction site respond to construction vibrations, with varying results ranging from no perceptible effects at the lowest levels, low rumbling sounds, and perceptible vibrations at moderate levels and slight damage at the highest levels. The vibration levels created by the normal movement of vehicles including graders, front loaders, and backhoes are the same order-of-magnitude as the ground-borne vibration created by heavy vehicles traveling on streets and highways. Therefore, operating this equipment would not cause any structural damage to adjacent buildings. The heaviest pieces of equipment such as pile drivers and vibratory rollers are the most dominant sources of construction vibration, and this type of equipment can potentially cause slight damage to adjacent structures. However, the closest structures are at least 50 feet (15 meters) away from the edge of La Fonda Bridge construction. It is possible for the residences in the closest residential structures to perceive construction induced vibration or even to be temporarily annoyed, but no structural damage due to the construction is anticipated.

If Soundwall S172 is determined to be constructed, this wall would be built in proximity to seven residential structures (144, 148, 152, 156, 160 164, and 200 Oak Way). Due to the presence of steep slopes and the lack of leveled terrain, it is mostly likely that hand-held augers will be used to prepare wall footings. Under the assumption of using hand-held augers, no structural damages are anticipated during construction. However, if hand held augers are not used, there would be vibration impacts.

9.0 REFERENCES

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APPENDIX A

NOISE MEASUREMENT DATA

APPENDIX B

SENSITIVE RECEPTOR AND NOISE BARRIER LOCATIONS

APPENDIX C

COST ANALYSIS

WORKSHEETS A AND B

APPENDIX D

CARDEN SCHOOL INDOOR/OUTDOOR NOISE MEASUREMENTS

APPENDIX E

COMPUTER NOISE MODELING INPUT/OUTPUT FILES